User Manual

H-1000XP Fuel Cell System

Date:2013-08-05

Part Number:H-1000XP

Version:20130805

Revision History

Release No.	Date	Revised by	Revision Description
Rev. 0	12/13/10	Tony	User's Manual draft
Rev. 0.9	12/24/10	WRP	1. Modified PART LIST 2. Modified GENERAL INFO 3. Modified SYSTEM SET UP 4. Modified SOFTWARE 5. Added MAINTENENCE
Rev. 0.95	01/13/11	WRP	1. Modified SAFETY 2. Modified SOFTWARE 3. Modified MAINTENANCE 4. Added TROUBLESHOOTING
Rev. 0.96	01/19/11	WRP	1. Modified Ultra Capacitor Bank
Rev. 0.97	02/10/11	WRP	1. Added note to Stack Holder 2. Added note to Hydrogen Sensor
Rev. 0.98	02/25/11	WRP	1. Modified Software Installation
Rev. 0.99	03/29/11	WRP	1. Added H2 sensor external power 2. Added fuse usage to Step 7 & 11
Rev. 0.99	05/11/11	WRP	1. Fix mistake of supply / purge valve direction arrow.
Rev. 0.10	05/23/11	WRP	1. Add note for not too long purge line. 2. Add warning for not to turn off by error protection.
Rev. 0.11	11/11/11	WRP	1. Modify H2 sensor related.
Rev. 0.12	05/02/12	Jason Stone	1. Added a blower controller 2. Modified the supply & purge valves 3. Changed the gas tube 4. Modified the DC/DC convertor
Rev. 0.13	07/12/12	Jason	1. Change the Dimensions value
Rev. 0.14	03/13/13	Jason	1. Change the input&output valves
Rev. 0.15	08/05/13	Jason	1. Change the Stack Holder color

OVERVIEW OF THE SYSTEM

Thank you for choosing our fuel cell stack. The Horizon fuel cell stack is an air-cooled, light weight and compact fuel cell stack.

H-1000XP is specially developed for SHELL Eco-marathon event,(please refer to www.shell.com/**ecomarathon/** for more details), this system has been designed according to event rules, it only needs a start up battery(12V) to start the system and will be self-sustainable after that, some of the features may not be necessary for other applications, please contact HORIZON for more details

Please read all instructions carefully prior to product use and keep this manual for future reference.
Further copies can be obtained from Horizon Fuel Cell Technologies or by emailing: support@horizonfuelcell.com
Please refer to the Horizon website for latest information: www.horizonfuelcell.com

Actions that will void the fuel cell and controller warranty:

● Do not attempt, under any circumstance, to disassemble or inappropriately tamper with the fuel cell.
● Operate the fuel cell with a controller not designed and built by Horizon for the specific fuel cell.
● Operate the fuel cell with valves and blowers that are not provided by Horizon for the specified fuel cell and controller.
● Disassemble the fuel cell
● Disassemble the controller
● Operating the fuel cell and controller that is no that is not in the setup and/or specified in the user manual provide for the specific product.

IMPORTANT

In order for the warranty to come into effect the stack must be registered on the Horizon Warranty Page at: www.horizonfuelcell.com/warranty.htm

Disclaimer

Information contained in this data sheet is considered to be accurate and reliable, to the best of our knowledge, at time of printing. However, we do not guarantee or warrantee its accuracy, reliability or completeness. Information may be subjected to revision and edition at our discretion. It is the User's obligation to use the product safely and within the scope advised in this publication. Information relates only to the specific product/material mentioned and may not be applicable where such product/material is used with any other.

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Terminology

PEM fuel cell:
A PEM (Proton Exchange Membrane) fuel cell is a device that converts hydrogen and oxygen into water and electricity.

A fuel cell stack:
It includes a plurality of plate-like fuel cells arranged along an axis generally parallel to cell thickness with electrically conductive separator plates between each pair of cells.

Reactants:
Reactant is a material used to start a chemical reaction. In the fuel cell the reactants are air and hydrogen by which the electricity will be generated.

Humidification:
A process to humidify the proton exchange membranes for optimal performance.

Blower:
Fans attached to fuel cell stack to supply cooling air and process air.

Purging valve:
Excess water and hydrogen will be dispelled from the fuel cell flow channels via purge valve.

SCU:
Short circuit unit – the short circuit will be controlled for good performance of the stack.

Mass flow per minute:
The amount of hydrogen consumed to run the fuel cell at a certain power.

HFCT:
Horizon Fuel Cell Technologies

Blower controller:
When no load is connected, turn off the blower controller to reduce the power consumption of the stack.

1.0 SAFETY

1.0 SAFETY

NOTE: The safety guidelines included here may not cover every situation. Use common sense.

1.1 General Information

For this unit to generate electrical power, a supply of hydrogen fuel is necessary. It is important for any operator to be aware of, understand, and follow all local safety requirements related to the handling of hydrogen and compressed gases.

The fuel cell system has built-in safeguards and is designed to shut down automatically if any out-of-range operating condition occurs. Possible situations include low cell voltage, high current, high temperature, or hydrogen leak detection.

• Do not dismantle the H-1000XP system. Contact HORIZON if you have any concerns about operation.

1.2 Using Hydrogen

WARNING! FIRE OR EXPLOSION
Keep all sources of ignition away from hydrogen.

This unit uses hydrogen fuel. Hydrogen is a colorless, odorless and flammable substance. It is highly combustible in the presence of oxygen and burns with a colorless flame.

Leaking gas may be hot and pose a burn danger. Stop the flow of gas – if you are not in danger – and use water to cool the area. If fire occurs, do not attempt to extinguish flames, allow the fire to burn out.

Prevent overexposure to hydrogen. Hydrogen is non-toxic but can act as a simple asphyxia by displacing the oxygen in the air. There are no warnings before unconsciousness results. When operating the H-1000XP power module in an enclosure:

• Ensure ventilation slots are clear and unobstructed at all times during operation
• Operate within the temperatures limits stated on the H-1000XP system nameplate
• Never operate if an alarm condition exists

1.3 Handling Compressed Gas Cylinders

WARNING!
Do not handle compressed hydrogen gas cylinders without training or experience.

• Use a pressure regulator to control the fuel inlet pressure to the system.
• Do not alter the fitting on a regulator. Ask experienced personnel for help.
• Do not attempt to force gas cylinder threads.
• Never transport a gas cylinder with regulators attached. Ensure cylinder caps are in place. Always use a cylinder cart with a safety strap or chain.
• Secure a high-pressure cylinder to a bench, post, or fixed object to avoid accidental contact.
• Avoid unnecessary contact with On/Off valves. They can easily move to “On” by accident.

1.4 Hydrogen Leakage

Hydrogen is colorless, odorless and tasteless. Hydrogen is non-toxic but can act as a simple asphyxiated by displacing the oxygen in the air. There are no warning symptoms before unconsciousness results.

WARNING!
Inhaling hydrogen can lead to unconsciousness and asphyxiation.
Hydrogen molecules are smaller than any other gas, making hydrogen more difficult to contain. It can diffuse through many materials considered airtight. Fuel lines, non-welded connections, and non-metal seals such as gaskets, O-rings, pipe thread compounds and packings present potential leakage or permeation sites. Furthermore, hydrogen’s small molecule size results in high buoyancy and diffusivity, so leaked hydrogen will rise and become diluted quickly.

Constant exposure to hydrogen causes hydrogen embrittlement in many materials. The mechanisms that cause hydrogen embrittlement effects are not well defined. Factors known to influence the rate and severity of hydrogen embrittlement include hydrogen concentration, hydrogen pressure, temperature, hydrogen purity, type of impurity, stress level, stress rate, metal composition, metal tensile strength, grain size, microstructure and heat treatment history. Moisture content in the hydrogen gas may lead to metal embrittlement through the acceleration of the formation of fatigue cracks. Hydrogen embrittlement can lead to leakage or catastrophic failures in metal and non-metallic components.

As a preventative measure, H-1000XP must be operated in a well-ventilated area in order to inhibit potential hydrogen accumulation.

WARNING!
Always operate H-1000XP in a well-ventilated area and ensure that ventilation slots are unobstructed.

1.5 Flammability and Volatility

Hydrogen is flammable over concentrations of 4 – 75% by volume in air, and is explosive over concentrations of 15 – 59%. As a result, even small leaks of hydrogen have the potential to burn or explode. Leaked hydrogen can concentrate in an enclosed environment, thereby increasing the risk of combustion and explosion.

Hydrogen flames are pale blue and are almost invisible in daylight due to the absence of soot. Due to its high buoyancy and diffusivity, burning hydrogen rises unlike gasoline, which spreads laterally.

A flammable or explosive hydrogen mixture is easily ignited by a spark or even a hot surface. The auto-ignition temperature of hydrogen is 500 °C (932 °F). The energy of a hydrogen gas explosion is 2.4 times that of gasoline or methane for an equal volume. Hydrogen gas explosions are therefore more destructive and carry further.

WARNING!
A mixture of hydrogen and air is potentially flammable and explosive and can be ignited by a spark or a hot surface.

As in the presence of any fuel, all sources of ignition, including smoking, are not permitted in the vicinity of the system.

WARNING!
Keep all sources of ignition away. Smoking is not permitted in the vicinity of the H-1000XP

1.6 Oxygen Depletion

Oxygen is a colorless, odorless, non-toxic and tasteless gas. Oxygen is essential for life in appropriate concentrations.

Ambient air contains up to 21% oxygen. Oxygen levels below 19.5% are biologically inactive and may act as simple asphyxiates. Effects of oxygen deficiency may include: rapid breathing, diminished mental alertness, impaired muscular coordination, faulty judgment, depression of all sensations, emotional instability, and fatigue. As asphyxiation progresses, nausea, vomiting, prostration, and loss of consciousness may result, eventually leading to convulsions, coma, and death. At concentrations below 12%, immediate unconsciousness may occur with no prior warning symptoms.

WARNING!
Lack of oxygen can lead to unconsciousness and asphyxiation.

As a preventative measure, H-1000XP must be operated in a well-ventilated area in order to compensate for the oxygen used within the fuel cells.

WARNING!
Always operate H-1000XP in a well-ventilated area.

1.8 Electrical Safety

WARNING!
Avoid contact with an exposed fuel cell stack. Electrical shock can cause personal injury or death.

- Do not touch fuel cell plates or any electrical components at any time. A running fuel cell stack is a potential electrical hazard that can cause burns or electrical shock.
- Do not wear conductive metallic items when you are close to an exposed fuel cell stack.
- Minimize static discharge at all times If possible, ground all equipment to your common ground.
- Minimize conductivity. Avoid contact with surfaces that are in contact with water or gases. Do not operate or store in wet or damp conditions.
- Never use damaged extension cords.

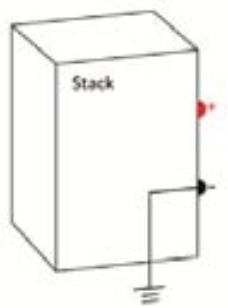
H-1000XP generates up to 48 VDC (open circuit voltage). This voltage decreases as current is drawn from the module. This voltage is exposed at the output power connections. These low voltages may constitute a shock hazard and can damage electronic components if shorted. Therefore, do not touch individual fuel cells, cell voltage monitoring equipment or electrical components.

WARNING!
Do not touch fuel cells, cell voltage monitoring equipment or electrical components.
Electronic components can also be damaged as the result of static discharge. To minimize this, ground all equipment in contact with H-1000XP. Never use damaged extension cords. Minimize conductivity by avoiding surfaces in contact with water; hands and clothes must be dry. Do not operate or store H-1000XP in wet or damp conditions.

WARNING!
Minimize static discharge. Ground all equipment.
Residual reactants within the H-1000XP can develop a charge in a matter of minutes when turned off. A reading of zero volts across the entire power module does not guarantee that all fuel cells are uncharged.

NOTE: The cathode has already been connected to the stack shell.

The stack cathode should be connected to common ground of all the equipments.



WARNING!
Always assume that the fuel cell stack is charged.
Jewellery (such as rings, necklaces, bracelets and watches) may concentrate an electric current when it comes into contact with charged components, or when a shock passes through the human body. Accordingly, no jewellery should be worn near H-1000XP.

1.9 High Temperature

The fuel cell stack is designed to operate above 60ºC sometimes, At this operating temperature, the air exhaust stream temperature can reach 55ºC and the cooling air stream can reach 17ºC above ambient conditions. These temperatures are sufficient to cause burns or severe discomfort. Accordingly, avoid contact with the fuel cell stack, or components that convey process or cooling air.

WARNING!
Avoid contact with the fuel cell stack or components that convey process or cooling air.

2.0 PART LIST

2.0 PART LIST

1. Stack

The H-1000XP fuel cell stack is a cathode-cooled proton exchange membrane (PEM) fuel cell stack designed to provide stable electrical power while operating on air and dry hydrogen. With innovative materials, the H-1000XP achieved 1000W power output with more efficiency comparing to standard H1000.

Tube size for hydrogen connector Φ6

2. Stack holder

It helps to fix the fuel cell stack on the place you want. There are 4 in the package. As showed on stack picture above, each side (left or right) can place 2.

NOTE: Please use bolts provided together with spring washer. Do not over tighten. The use of wrong screw length will damage the stack.

3. Hydrogen supply valve

Supply valve controls the H2 input. The supply valve will open when the system is operational. This valve will act as emergency shut down valve in the case of leakage in excess of 1% hydrogen in air when triggered by the hydrogen sensor. Please take note of the label and direction of the gas flow.

4. Hydrogen purging valve

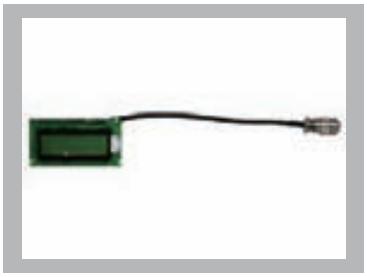
Purging valve: the controller will control the purging time For purging the water and air gas redundant in the fuel cells.

Please note the label and the direction of the arrow.

Tube size for hydrogen connector Φ6

5. SCU switch

It is to turn the SCU on/off. For SCU, Please refer to Terminology.



6. LCD display

It displays the system status, current, voltage, temperature etc.

Please refer to trouble shooting section for more details

7. Hydrogen sensor

It triggers at 25% of LFL, which is 1% hydrogen concentration.

Power supply for hydrogen sensor

Please attached this wire to your on-board battery (12V) to power the hydrogen sensor.

NOTE: This sensor has a delayed respond (for about 15 seconds).

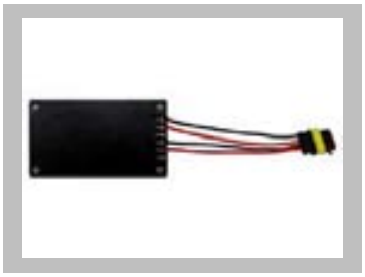
8. Start up battery connector

It is the connector which connect startup battery to the controller

9. Ambient temperature sensor

It senses the ambient temperature.

The sensor should be place opposite to the blower side of the fuel cell stack. As is showed in system set up section.



10. DC/DC converter

The DC/DC will regulate the output voltage for the controller. It can step down the stack voltage (27.5V to 48V) to 12V for the fuel cell controller and other peripheral parts.

11. Ultra capacitor bank

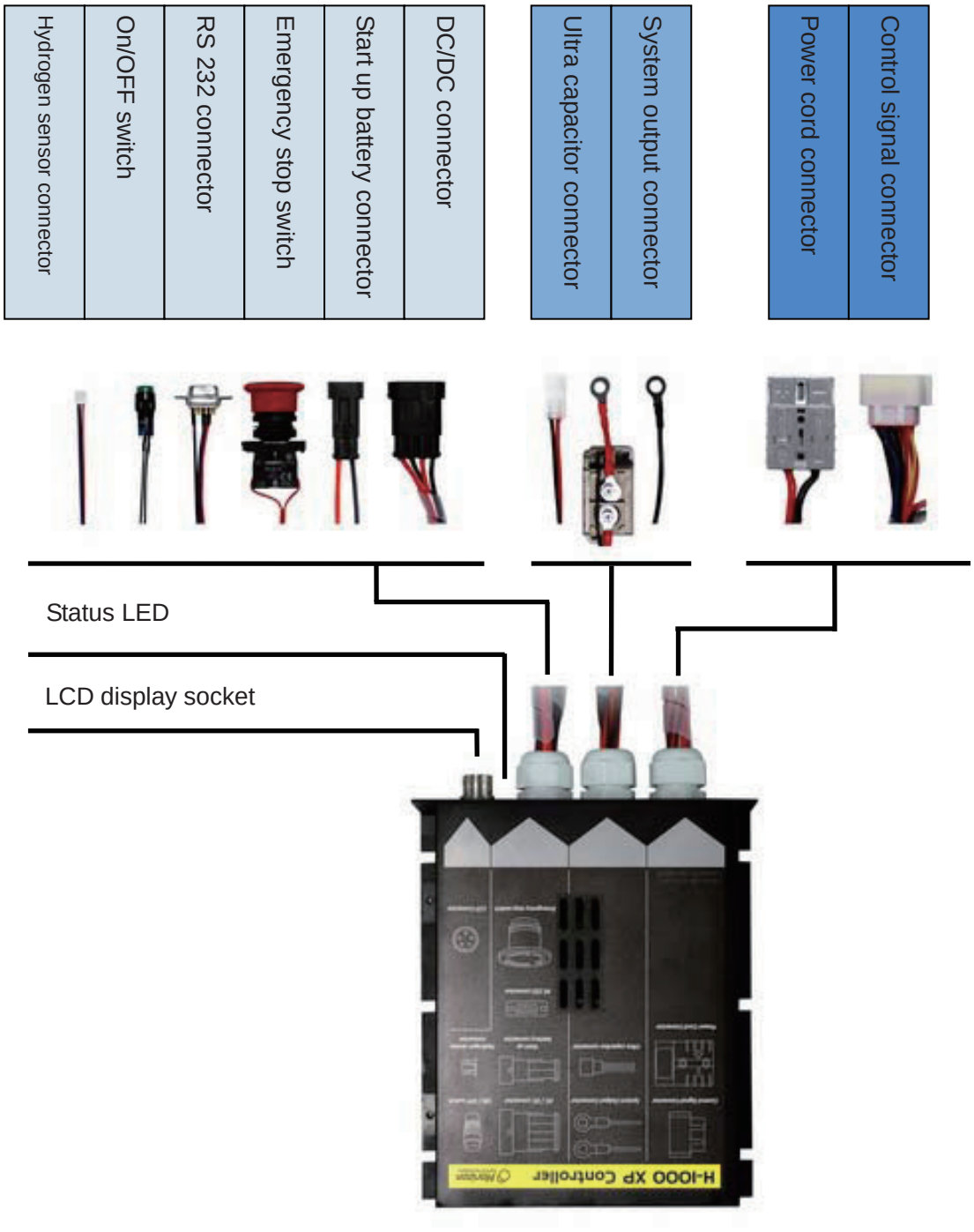
It can supply power output during system short-circuiting (please refer to Short Circuit Unit for more details), which could enable system continuous operation without external power supply
Rated voltage: 50V
Capacitance: 1.25F

If regenerative braking is required, please put a bigger ultra capacitor bank to store this energy.

If a higher capacity ultra capacitor is used, you can replace this set of capacitors. (Please note that the maximum voltage of the fuel cell is 48V, so size your ultra capacitors accordingly).

12. Blower controller

When no load is connected, turn off the blower controller to reduce the power consumption of the stack.

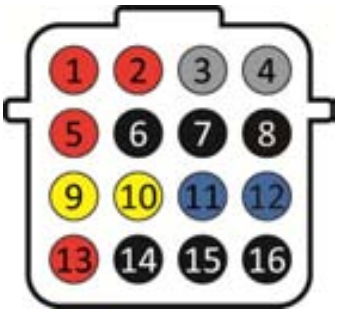


13. System controller

It controls the stack and all peripheral parts to perform at its optimal condition. It has the following features

- Control Stack temperature
- Control Stack purge rate
- Monitoring stack current and voltage
- Monitoring H2 concentration(H2 sensor needed)
- Protect stack from possible failures, like stack low voltage, over current, over temperature
- Control Hydrogen supply and shut off
- RS232 Communication with computer

Controller Signal Connector from Controller box at the wire side:



Wire colors	Connector pin #	Peripherals controlled
Red	#1 & #2	Stack Temperature Sensor
Grey	#3 & #4	Ambient Temperature Sensor
Red & Black	#5 & #6	Blowers (Red #5= +ve, Black #6= -ve)
Black	#7 & #8	Hydrogen Purge Valve (Black #7= +ve, Black #8= -ve)
Yellow	#9 & #10	Hydrogen Supply Valve (Yellow #9= +ve, Yellow #10= -ve)
Blue	#11 & #12	Short Circuit Switch
Red & Black	#13 & #14	N/A
Black	#15	N/A
Black	#16	Blower PWM

Table 2.1 Controller Connector

3.0 GENERAL INFORMATION

3.0 GENERAL INFORMATION

3.1 Dimensions

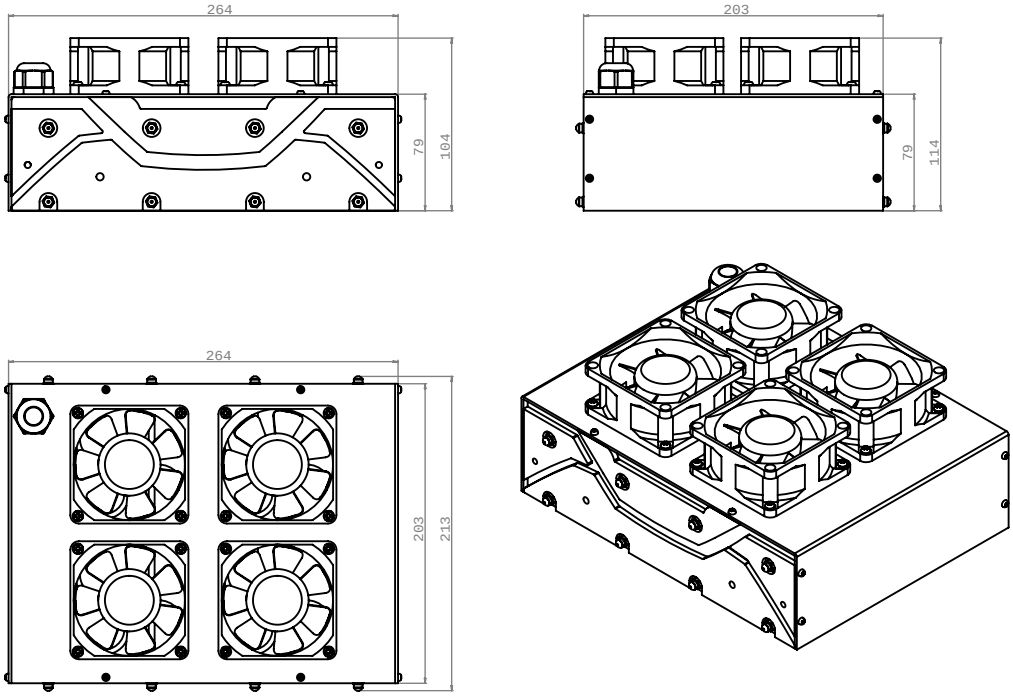


Figure 3.1.1 Views and dimensions of H-1000XP stack

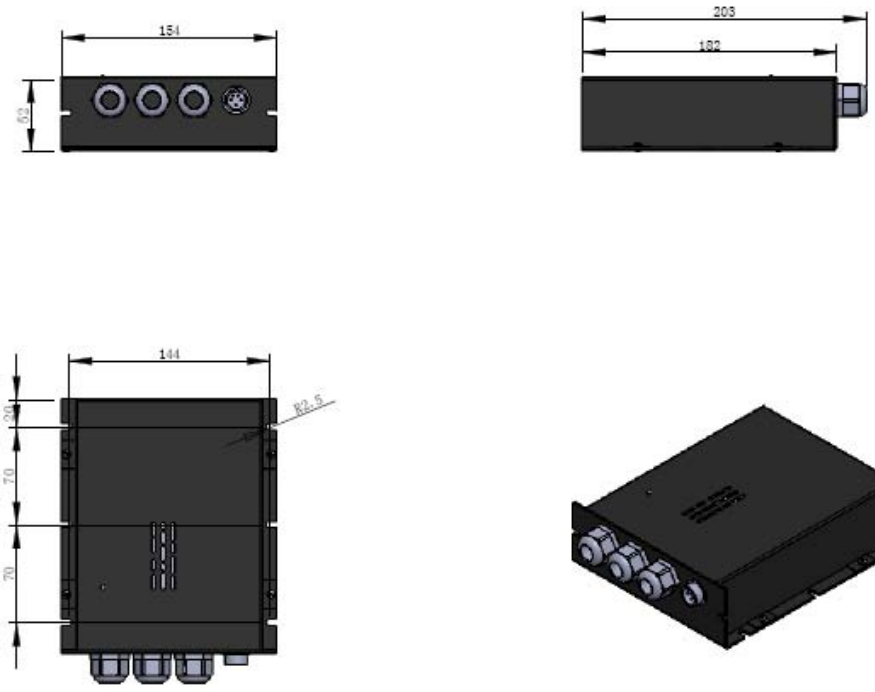


Figure3.1.2 Views and dimensions of controller

3.2 General specification

	Category	Value
	Type of fuel cell	PEM
Physical	Number of cells	50
	Dimensions	264mm x 203mm x 104mm
	Mounting	4 x M6
	Weight	stack less than 4.9kg
		system less than 6.8kg
Performance	Peak power	1100W
	Rated current	0 - 33.5A @ 30V
	DC voltage	25V - 48V
Fuel	Reactants	Hydrogen and Air
	Composition	99.99% dry H2
	H2 pressure	7.2 - 9.4 PSI
	Hydrogen consumption @1000W or flowrate	12.5SLPM
operation	External temperature	5 - 35°C
	Max stack temperature	65°C
	Humidification	Self-humidified
	Cooling	air
	Relative humidity	10%-95%RH non-condensing
	Start up battery	12V
Monitoring	RS232	System status / Historical data

Chart 3.2 General Specification of H-1000XP

3.3 Electric Circuit Diagram

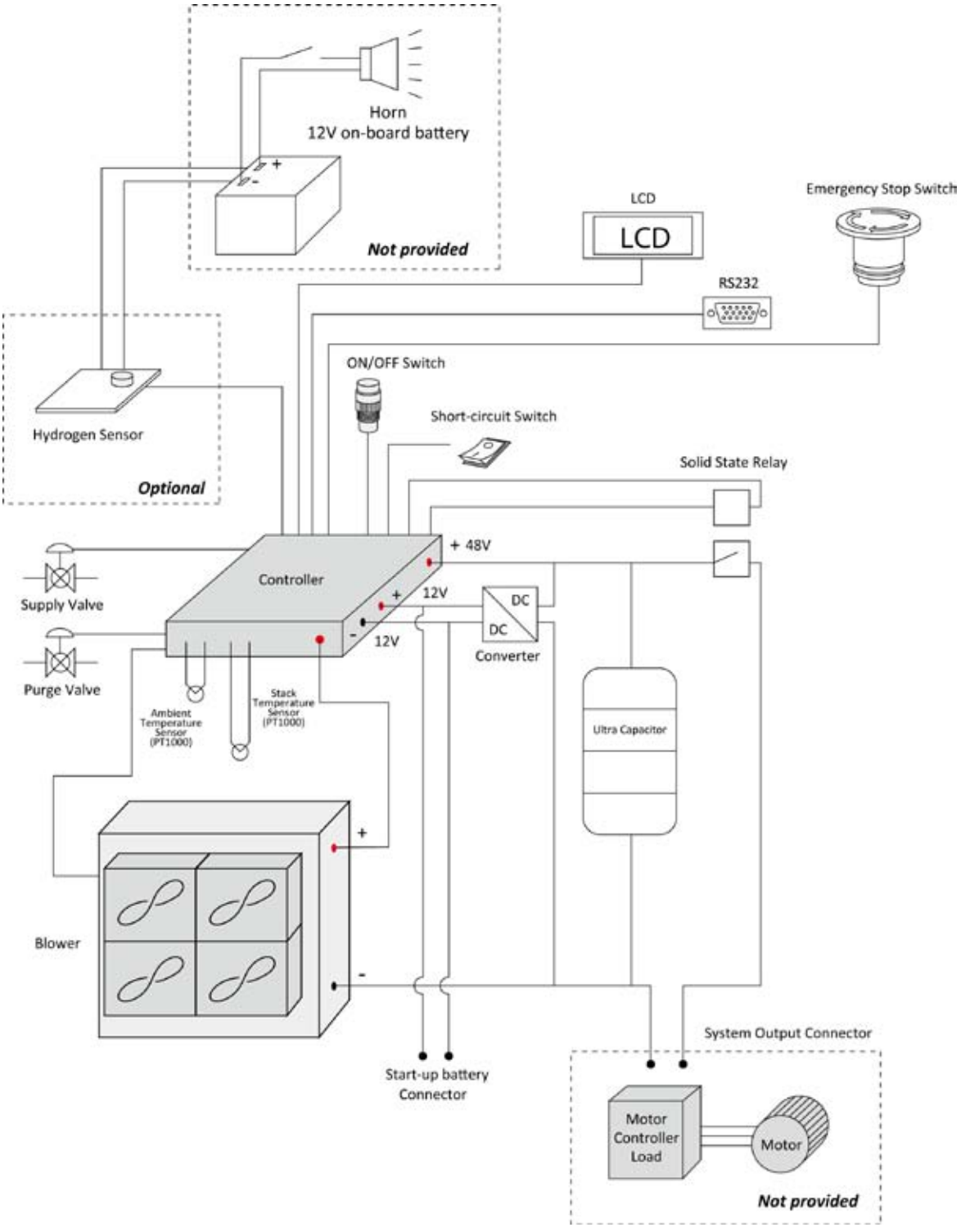


Figure 3.3 Electric Circuit Diagram for H-1000XP

Please refer to section 2.0 for more details of each part

3.4 H-1000XP Performance Specifications

The H-1000XP can deliver up to 33A of current. Its operating voltage ranges from 46V (no load) to 30V (full load). The rated operating point of 33A@30V is recommended.

NOTE: All the performances are under lab condition.

3.4.1 Nominal Polarization Characteristics

Figure 3.4 below shows the polarization curve for a fully conditioned H-1000XP system operating at nominal conditions and system-to-system variability bands of the fuel cell operating at normal room temperature. Nominal operating conditions are as follows:

- Steady-state operation(constant voltage mode)
- Stack oxidant supply (18-24° C, 25-35% RH, low levels of common urban pollutants such as nitrogen oxides and sculpture oxides).
- Anode dead-ended with adequate purge controlled by HORIZON controller
- 0.5 bar hydrogen inlet pressure

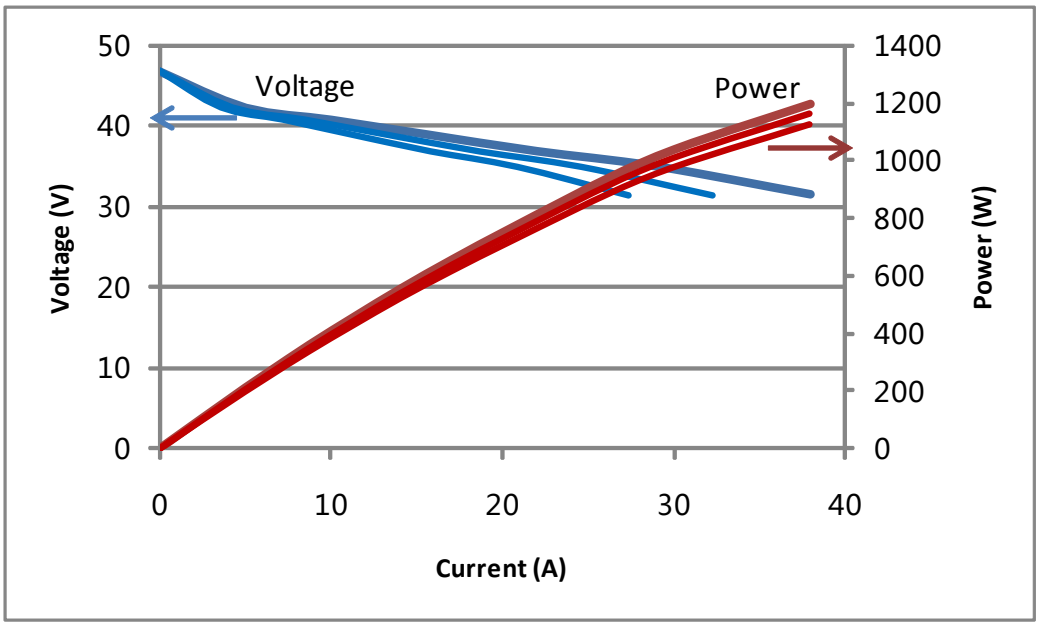


Figure 3.4.1 Polarization curve for H-1000XP

3.4.2 Stack degradation rate and lifetime

There are generally two key life-limiting failure modes that will prevent the stack from performing as required in a given application: voltage loss and fuel leakage. Voltage loss is seen as a steady degradation in maximum power. Fuel leakage will lead to both an increase in fuel consumption, and H2 emissions in the coolant air exhaust stream.

Testing has demonstrated that the H-1000XP stack has a mean lifetime of approximately 1000 hours and 300 on/off cycles under nominal operating conditions In general, to maximize stack life, avoid the following conditions:

- Fuel starvation (for example, due to low/high hydrogen pressure, or operating for significant periods of time below optimal ambient temperature)
- High operating temperatures (operating for significant periods of time above optimal ambient temperature)
- Contaminants in the coolant/oxidant air
- Contaminants in the fuel
- Open storage. When the stack is stored over a long period of time in a dry condition (in air conditioned room). The MEA will be dehydrated and performance of the fuel cell will decrease. Please store the stack in an airtight container when not in use.

3.4.3 Peak power output

The H-1000XP can deliver a peak power output of 1200W* to meet the high power requirements during vehicle climbing hills. This is realized by connecting an ultra capacitor in parallel hybrid configuration. Fuel cell also recharges the capacitor when excess power is available during cruise.

Please refer to section 2.0 for more details of ultra capacitor

3.4.4 System hydrogen consumption rate

Figure 3.4.4 presents the fuel consumption rate of the H-1000XP system at different power outputs. The data is recorded in Nominal operating conditions (please refer to 3.4.1 for more details)

Please NOTE the fuel consumption will also vary with ambient temperature, since high ambient temperature will require higher fan power consumption and also it will affect the fuel cell stack performance,

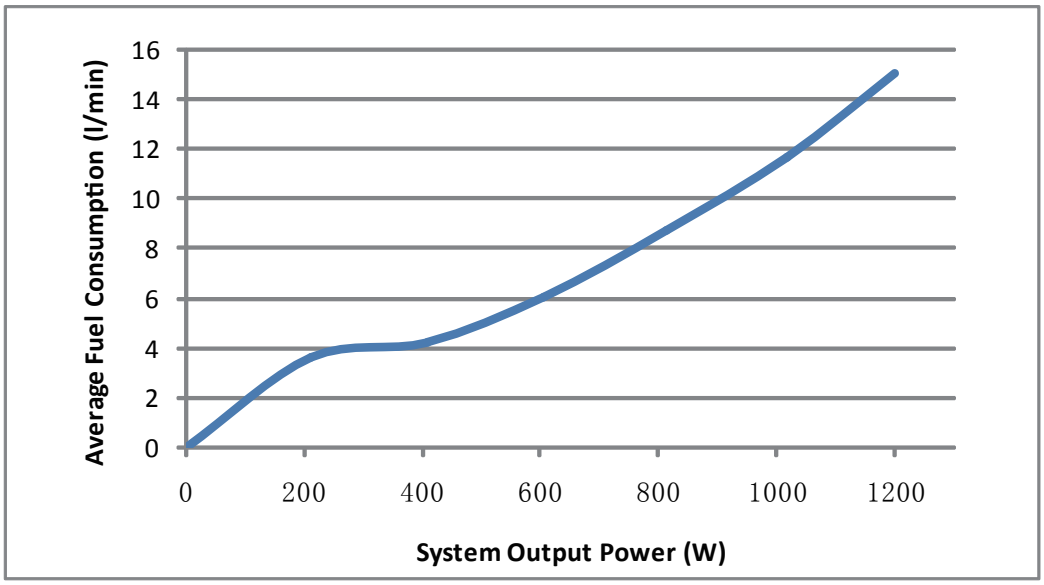


Figure 3.4.4 System hydrogen consumption rate

0W	211.5W	408W	604.5W	811.8W	1015W	1091.2W
0.0L/min	3.59L/min	4.19L/min	6.07L/min	8.71L/min	11.69L/min	15L/min

The following formula is used to calculate the system efficiency

Energy content of 1 kg hydrogen	120.1 MJ (LHV) = 33.3 kWh

⇨ (1000 / 2) x 22.4 L/mol hydrogen generates 33.3kWh energy

⇨ 1L/min hydrogen generate 178.361W power

Take 211.5W point for example, the hydrogen consumption is 3.59L/min

Therefore this amount of hydrogen could generate 3.59x178.361 = 640W power

Then the system efficiency is 211.5 / 640 = 33%

3.4.5 Airflow requirements

Fuel cell system requires airflow for reaction oxidant as well as cooling. Figure 3.4.5 below shows the estimated airflow requirements of the H-1000XP at different power outputs.

Slight contaminant level in the operating environment has insignificant effect on the H-1000XP performance over the full product lifetime. Exposure to high level of contamination in the operating environment will lead to a drop in performance drop, which may or may not be recoverable. If the operating environment is expected to be very dusty, filter for the oxidant and cooling air may be required.

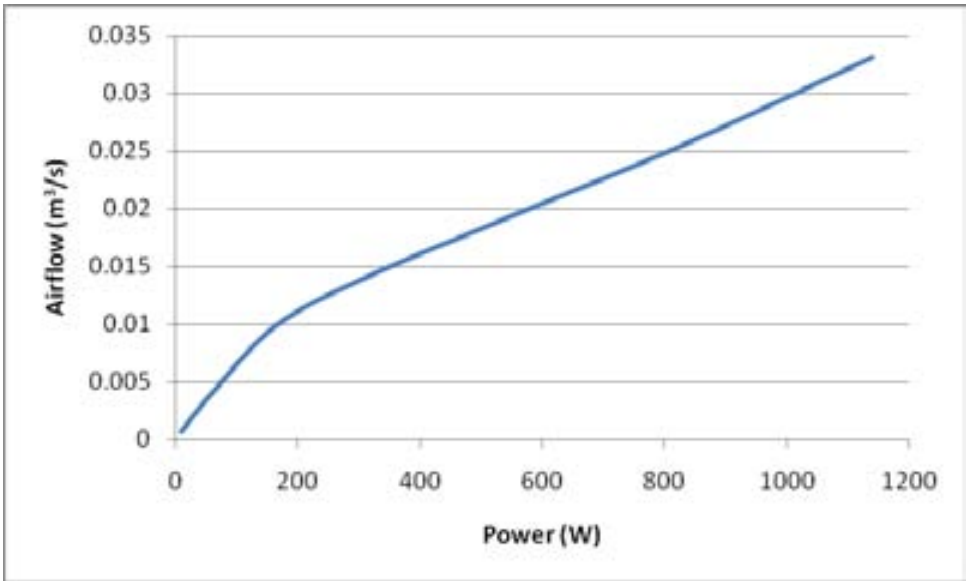


Figure 3.4.5 Airflow curve for H-1000XP system

3.4.6 Ambient temperature

One factor that affects the H-1000XP performance is ambient temperature. Higher temperature leads to the drying up of the proton exchange membranes inside the fuel cell stack, reducing proton conductivity and consequently the power output of the fuel cell.

The H-1000XP can deliver its rated performance when operating at ambient temperature ranging 0-35° C* and a relative humidity range of 10-90%. At a given environment temperature, the H-1000XP performance increases with a higher level of relative humidity.

3.5 Control and Communication

Communication channel: RS232 serial byte format, 9600 bps, 8 data bits, no parity, 1 stop bit; Little-endian format.

Message frequency: 1k Hz.

Reportable parameters:

Name	Data Range	Resolution	Baud rate	Frequency(Hz)
Fuel Cell Stack Voltage	25-50V	0.3V	9600	1k
Fuel Cell Stack Current	0-60A	0.3A	9600	1k
Fuel Cell Power	0-1500W	1W	9600	1k
Fuel Cell Stack Temperature	0-70	0.5C	9600	1k
Battery Voltage	11-14V	0.2V	9600	1k

Table 3.5 RS232 data and format

4.0 SYSTEM SET UP

4.0 SYSTEM SET UP

To operate H-1000XP, the following items and resource are needed,

- 12VDC Start up power source
- Hydrogen source(operating pressure: 0.5bar / flow rate: 15SL/MIN)

H-1000XP is a self-sustainable system once it is started, to start up the system, a 12V power source is required, and it could be a battery (current above 4Ampere) or a 12VDC power supply with current above 4Ampere

please follow the steps carefully to set up the system，please DOT NOT feed the system with hydrogen and DO NOT connect power supply to the controller before all parts are properly connected.

4.1 Setup gas line to the stack

Since H-1000XP stack has two hydrogen inlet port and two outlet port, therefore a proper gas line need to be connected to make the system work as designed, please DO NOT mismatch hydrogen inlet and outlet port, which will result in stack under performance and possible damage!!! Please refer to the label on the stack and pay special attention to the arrow on the solenoid valve.

Figure 4.1

Figure 4.2

Step 1

Make gas line for hydrogen inlet, connect two tubes(**Φ6 /** prefer each tube length less than 50cm) to the three way port, as showed in fig 4.1 and 4.2,

Repeat step 1 to make a gas line for hydrogen outlet

Figure 4.3

Step 2

Please place the stack in vertical like this. Then connect the gas line finished in step 1 to stack hydrogen inlet port, as showed in fig 4.3.

WARNING!
Do not place anything in front of or back from the stack, which may block off the air flow.

Figure 4.4

Step 3

Connect the gas line finished in step 1 to stack hydrogen outlet port, as showed in fig 4.3 & 4.4.

Figure 4.5

Step 4

Connect the hydrogen purge valve to the hydrogen outlet gas line; please pay attention to the flow direction on the valve body, as showed from fig 4.5 to 4.8.

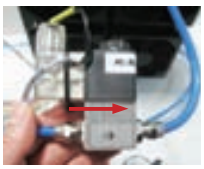


Figure 4.6

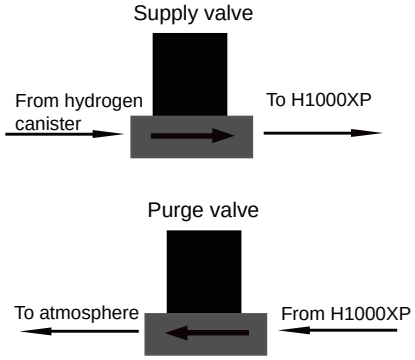
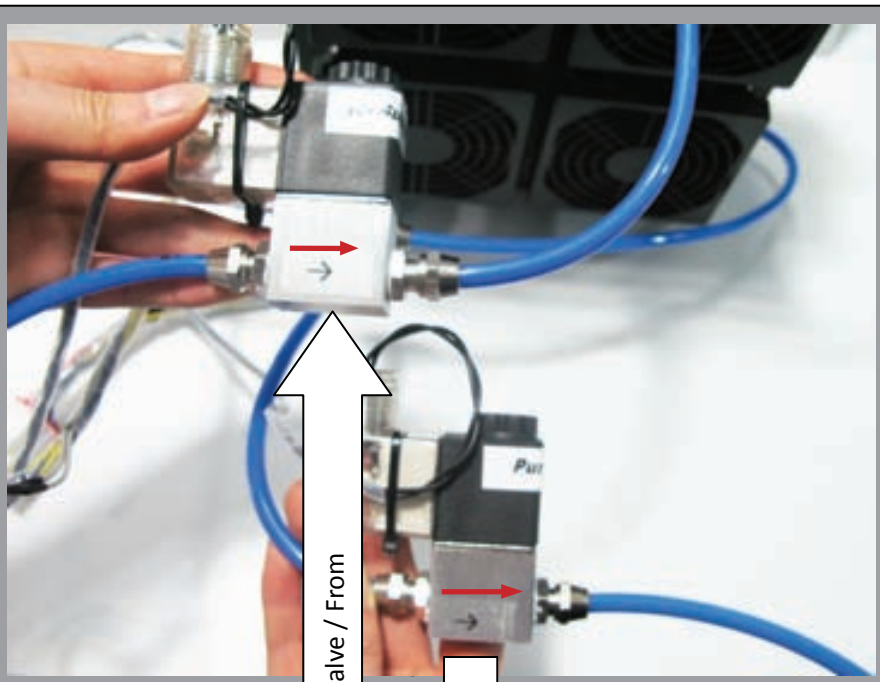


Figure 4.7



Please avoid positioning the purge valve near the air inlet side. Always position the purge valve on the blow side of the stack. If the purged hydrogen is in contact with the stack, the MEA will be damaged permanently.

Please keep the hydrogen purge line away from the stack, it is recommended that keep the purge line at the stack fan side, as the air will blow purged hydrogen away. It is strictly prohibited that leave the purge line.

Connect your hydrogen supply to the hydrogen supply valve, please DO NOT turn your hydrogen until the system is fully set up. Please make sure hydrogen is 0.5bar/15SLPM at no load and during full load.

NOTE: Be sure the purge line is NOT TOO LONG (better within 0.2m) from the purge valve, so that it will not do harm to stack purging easily.

4.2 Setup controller

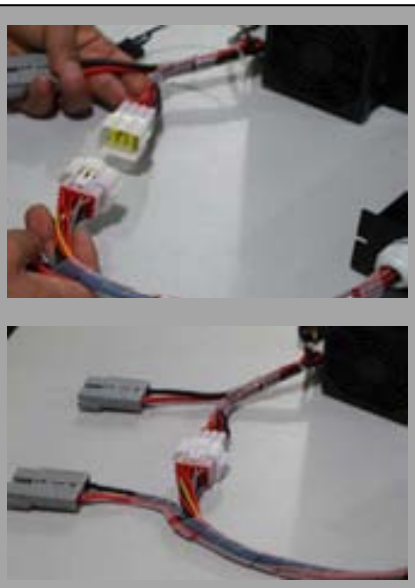


Figure 4.9

Step 5

Connect control signal connector to the stack, as showed in fig 4.9

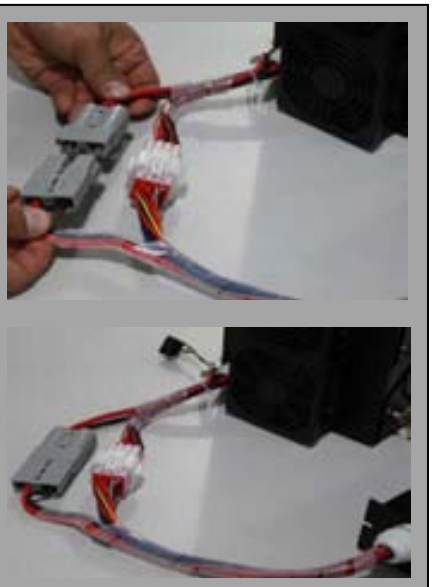


Figure 4.10

Step 6

Connect power cord connector to the stack, as showed in fig 4.10

Figure 4.11

Step 7

Connect ultra capacitor connector to the ultra capacitor bank, as showed in fig 4.11

A fuse is to be installed on the positive side of the capacitor bank (not provided). This fuse rating will varies from team to team and must be according the Chapter 1 Shell Eco Marathon Rules.

Figure 4.12

Step 8

Connect DC/DC connector to the DC/DC convertor, as showed in fig 4.12

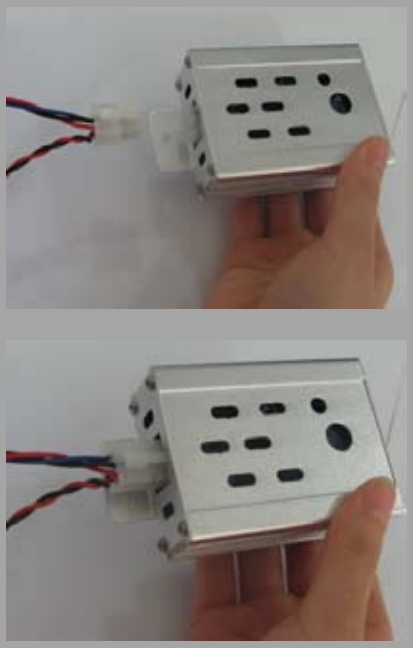
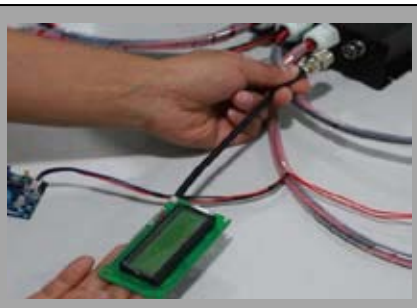


Figure 4.13

Step 9

Connect hydrogen sensor to the hydrogen sensor connector, as showed in fig 4.13

Please note that some application will not require this component and system will still work without this part



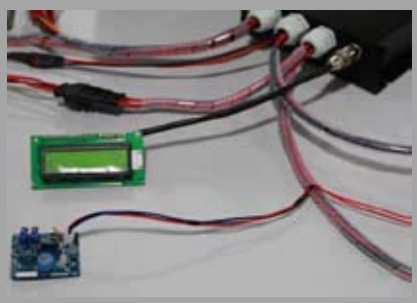


Figure 4.14

Step 10

Connect LCD display to the controller LCD connector; please note system could run without this part, as showed in fig 4.14

Figure 4.15

Connect the hydrogen sensor to on-board battery to power the safety circuit, as showed in fig 4.15

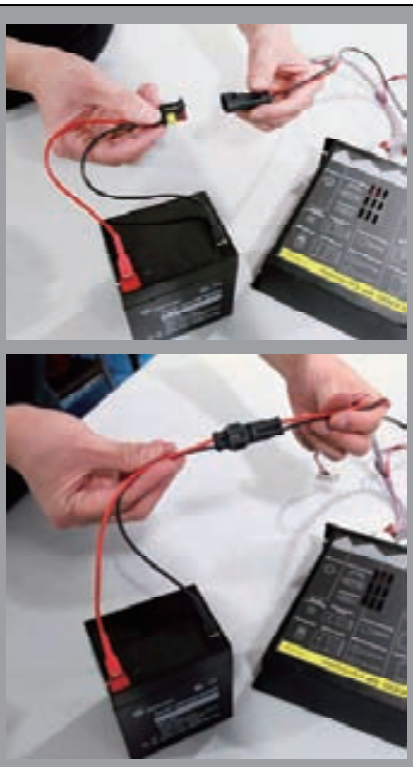


Figure 4.16

Step 11

Connect the start up battery (not included in the system); it could be any DC power source with 12VDC, current above 4ampere.

First, connect the cable to the start up battery.

Then plug the cable connector to the controller, as showed in fig 4.16

Figure 4.17

NOTE: It is NOT suggested to plug the battery cable to the controller BEFORE it connects to the battery, as showed in fig 4.17.

Warning!
Please observe the polarity of the wire. Wrong polarity will damage the controller.

Figure 4.18

Step 12

It is highly recommended to connect rs232 to your computer to record system operation data, as showed in fig 4.18 Please refer to the software section for more details

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Figure 4.19

Step 13

Please make sure the emergency stop switch is at off position, otherwise the system is unable to start

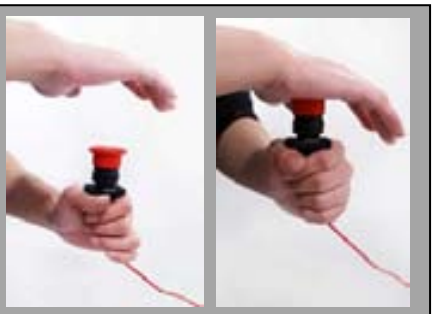


Figure 4.20

Figure 4.21

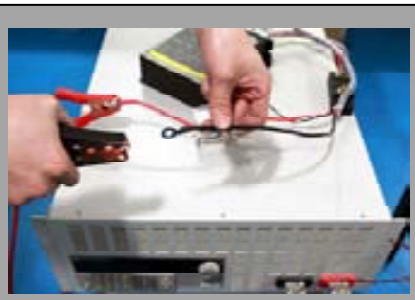
Step 13

To turn on: Push the button, as showed in fig 4.20

To turn off: Wheel the button till it is up, as showed in fig 4.21

Figure 4.22

Figure 4.23



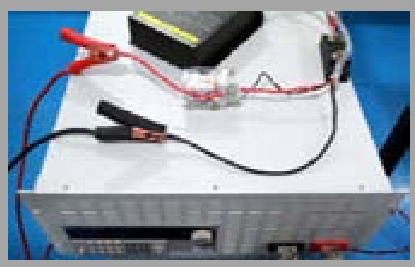


Figure 4.24

Step 14

Connect the load cable to your load, it is suggested that please do not turn on the load before system start up.

NOTE: The clamp is NOT suggested to use for connecting。You may find other tools to make the connection more reliable. This way is only for example.

A fuse is to be installed on the positive side of the fuel cell terminal. This fuse rating will varies from team to team and must be according the Chapter 1 Shell Eco Marathon Rules.

4.3 Ready to start up

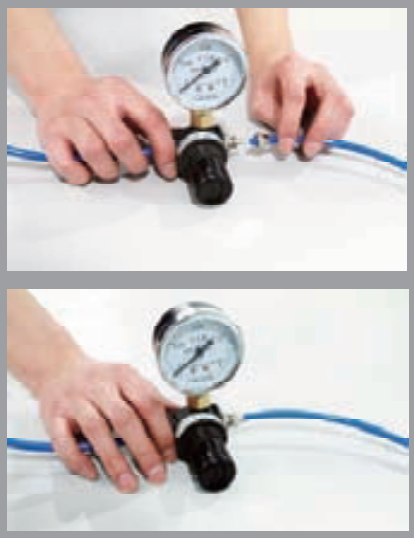


Figure 4.25

Step 15

Please find the tube to the Hydrogen supply valve, connect it to the regulator. Then set the regulator value to operating pressure: 0.5bar/15SLPM.

NOTE: The type of the regulator used for example may be different from yours.

Figure 4.26

Warning!

Make sure the pressure of the hydrogen supply is maintained at 0.5 barg. This is critical especially during high flow rate at higher power output.

Figure 4.27

Step 16

Please place the ambient temperature sensor opposite to the blower side of the stack. The place where the air comes in

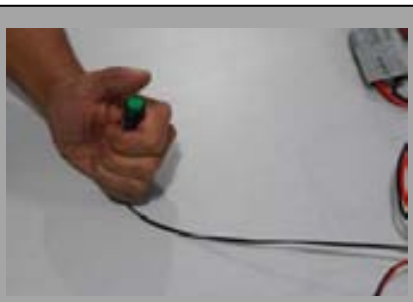


Figure 4.28

Step 17

Check all the connections first, including the gas and the electricity. Be sure there is no problem of disconnecting.

Now it is ready to start the system by long press the button (3 seconds)

Figure 4.29

Come to booting up phase, system beeps for a short moment, flash the blue LED, display "Horizon /Fuel Cell" on the LCD.

Figure 4.30

Come to running phase, the blue LED will light on, the LCD displays:
E for ambient temperature;
B for battery voltage,
T for stack temperature,
I for stack current,
U for stack voltage.

Figure 4.31

Step 17

If the red LED flashing with the beeps, the system comes to the error protection status.

For example, the LCD displays "SYSTEM OFF FOR: FCVOLTAGE LOW" means the stack open circuit voltage is too low, and the system will shut off for protection.

For more, please refer to troubleshooting section.

4.4 System manual shut off

Figure 4.32

Step 18

Long press the button (3 seconds)

System beeps and LCD displays "SYSTEM OFF FOR: MANUAL TURN OFF"

WARNING!
Do not attempt to let outside load run out all the energy from fuel cell or other ways may cause system shut down by error protection, if you want to turn off the system.

5.0 SOFTWARE

5.0 SOFTWARE

Introduction

ECO-Marathon Serial Port Monitor is software, which is developed to help user to communicate with ECO-Marathon system, monitor and record various information, including: Ambient Temperature, Stack Temperature, Stack Voltage, Stack Current, Stack Power, Battery Voltage and Stack Status.

5.1 Features

1. System Monitoring
    a) Ambient Temperature Monitoring
    b) Stack Temperature Monitoring
    c) Stack Voltage Monitoring
    d) Stack Current Monitoring
    e) Stack Power Monitoring
2. Real-time Curves
    a) Ambient Temperature Curve
    b) Stack Temperature Curve
    c) Stack Voltage Curve
    d) Stack Current Curve
    e) Stack Power Curve
    f) Battery Voltage Curve
3. History Display
    a) Display Result
    b) Save to File

5.2 Environment

Hardware Environment

1. Desktop or Laptop with Serial Port
2. Serial Cable(RS232)

Or

1. Desktop or Laptop with USB
2. USB To RS232 Cable with driver

Software Environment

1. Microsoft Windows XP or above (32bit)

5.3 Installation

1. Put the installation CD into the CD-ROM drive.
2. Run Setup program.

NOTE: Better to install the program on a root directory. E.g. C:

5.4 Usage

Open program

1. Find “ECO-Marathon Monitor” in “START\All Programs”.
2. Click the icon to open.

Configuration

1. Select I/O Port which is to connect to the ECO-Marathon system.
2. Set Timeout (Default is 100s).
3. Set REC ON/OFF, whether to record data or not.
4. Set recording Period (Default is 1s).

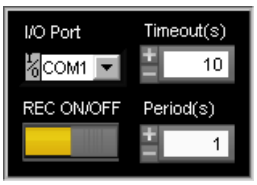


Figure 5.1 Configuration

Run & Stop

1. After the configuration, press the RUN button on the top left corner to run the program.

Figure 5.2 RUN button

2. Press STOP button on the top right corner to stop the program.

Figure 5.3 STOP button

Monitor Panel

1. Ambient Temperature, Stack Temperature, Voltage, Current, Power will display as meter and number on this panel.

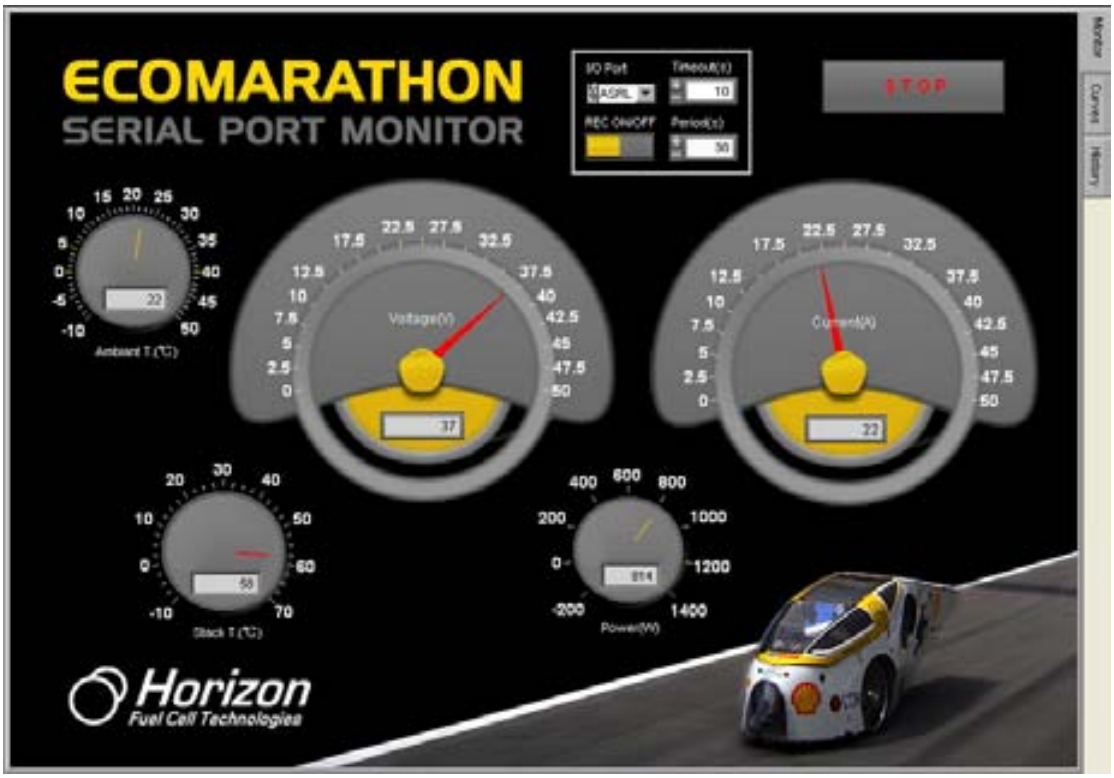


Figure 5.4 Monitor panel

Curves Panel

1. Ambient Temperature, Stack Temperature, Voltage, Current, Power, Battery Voltage will display as real-time curves on this panel.

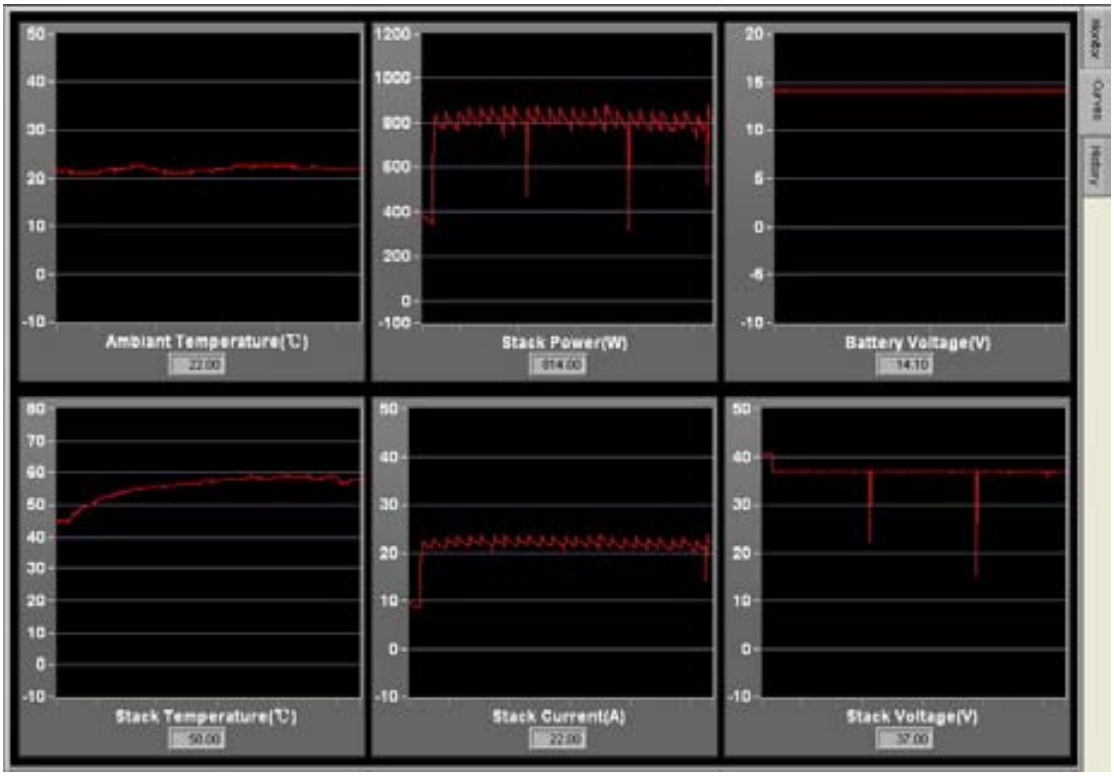


Figure 5.5 Curves panel

History Panel

1. User select the time from the pull down list.

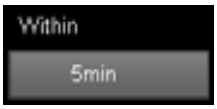


Figure 5.6 Pull down list

2. Press the DISPLAY RESULT button, the history data will display in the result records table.

Figure 5.7 DISPLAY RESULT button

3. Press SAVE TO FILE button, the results will save in the data directory as an EXCEL file.

Figure 5.8 SAVE TO FILE button

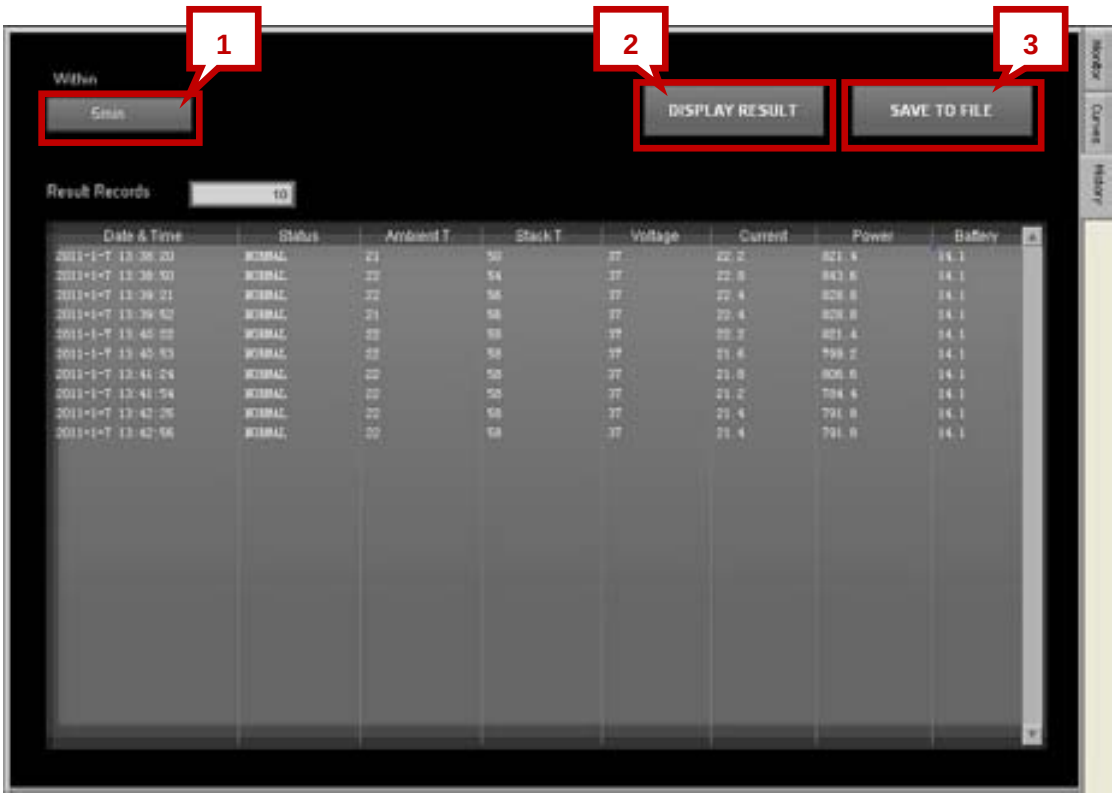


Figure 5.9 History panel

5.5 Error Information

1. Connection Timeout Error

c) Phenomenon

A dialogue window will pop up as follow:

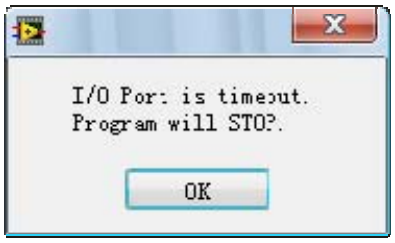


Figure 5.10 Monitor panel

d) Description

ECO-Marathon Serial Port Monitor lost connection to the system.

6.0 MAINTENANCE

6.0 MAINTENANCE

When finished operating the stack, we highly suggest that inject pure water into the stack before place it back in the supplied air tight container to keep the stack from getting too dry.
Injecting water into the stack:
1. Connect a short section of hosing to the gas port marked “H2 Input” and another one to the”H2 Output” port.
2. Fill a syringe with pure water (distilled) and connect it to the hose attached to the “H2 Input” port.
3. Inject pure water into the stack until you see water coming out of the hose connected to the “H2 Output” port. Keep the water inside the stack. Disconnect the syringe.
4. We strongly recommend you connect a small hose to both “H2 Input” and “H2 Output” ports.

If the stack is un-used for a long period of time (more than 4 weeks):
Rejuvenate by injecting water into the stack before use:
1. Connect a short section of hosing to the gas port marked “H2 Input” and another one to the”H2 Output” port.
2. Fill a syringe with pure water (distilled) and connect it to the hose attached to the “H2 Input” port.
3. Inject pure water into the stack until you see water coming out of the hose connected to the “H2 Output” port. Keep the water inside the stack for about 5 minutes. Now disconnect the syringe, and leave the water in the two hoses.
4. Purged the water out of the stack thoroughly before use. This is done by connecting the H2 supply to the stack, without a load attached, and purging the stack thoroughly (i.e. letting hydrogen flow through the stack to remove water and other contaminants). Make sure the hydrogen supply pressure is not >0.5bar.

WARNING!
1. Please make sure you have purged the water out of the stack thoroughly before use.
2. Using the fuel cell stack with water inside can irreparably damage it!

WARNING!
Disconnect the hydrogen supply completely if the fuel cell is not in operation for more than 30 mins. This is to stop hydrogen gas leaking into the fuel cell and destroying some of the parts.

WARNING!

When you turn off the on/off switch connected to the control box at the temperature of the fuel cell stack higher than 45˚C the stack will not stop working immediately. Only when the stack temperature goes down below 45˚C, the whole system will stop operation in order to protect the stack.

So in order to make it work well, the fuel cell stack must be maintained lower than 45˚C before operate the on/off switch.

WARNING!

The stack must be standing on the clear plastic feet.

WARNING!

Before the load is connected, turn on the blower controller. Otherwise the load will not run. During the operation process, do not turn off the blower controller.

7.0 TROUBLESHOOTING

7.0 TROUBLESHOOTING

LCD, LED and Beep of the status during procedures

#	Procedure	LCD	LED	Beep	Status	System Reaction
1	Starting up	Horizon /Fuel Cell	Green flashing	Long beep	Normal	Starting up
2	Starting up	System off/Battery Low	Red flashing	Long beep	Battery voltage is too low	Shut down
3	Starting up	System off/FC Voltage Low	Red flashing	Long beep	Stack voltage is too low	Shut down
4	Starting up	System off/H2% High	Red flashing	Long beep	Hydrogen leaks	Shut down
5	Running	E: B: T: U: I:	Green light on	NONE	Normal	Running
6	Running	System off/FC Voltage Low	Red flashing	Long beep	Stack voltage is too low	Shut down
7	Running	System off/H2% High	Red flashing	Long beep	Hydrogen leaks	Shut down
8	Running	System off/Current High	Red flashing	Long beep	Stack current is too high	Shut down
9	Running	System off/T High	Red flashing	Long beep	Stack temperature is too high	Internal load will switch off until stack temperature is satisfied

Rehydrating the fuel cell because the stack cannot reach the rated power

1. Make sure the purging valve is disconnected from the hydrogen outlet connector.
2. Add water to fuel cell through the hydrogen inlet connector, and keep filling until water starts to come out of the hydrogen outlet valve.
3. Immediately use the hydrogen supply valve to connect the hydrogen supply the hydrogen inlet connector. Pay attention to the hydrogen supply direction.
4. Make sure the hydrogen supply pressure is not >0.5bar.
5. Open the hydrogen supply. Turn on the on/off switch for purging the water out of the fuel cell.
6. Steps 1-5 should only take 5-10 seconds to do.
7. Setup the fuel cell system again for general operation.
8. With the SCU switch on, start the fuel cell again.

Battery voltage is too low

Please check if start-up battery connector is ok.
Or the battery might not be operating correctly or in the case of a battery may not have any charge left.

1. Disconnect the external power source.
2. Using a multimeter take a reading of the positive and negative connection points on the external power connectors to the controller.
3. If the power is <12V then the power is not coming through to be able to power the controller, blowers and valves.
4. Change or recharge your power supply and check the voltage that it meets the fuel cell voltage before connecting it up to the controller.

Stack voltage is too low

1. Please check if supply/purge valve is open.
2. Please check if the blowers are running slowly, or not running at all.

Hydrogen leaks

Please check if the gas line has no leakage, including gas tubings and gas connectors, etc…

If the system shuts down by itself check the following details

1. Make sure you have connected all wires according to the diagram.
3. Make sure you have connected the hydrogen supply with the correct pressure.
4. Make sure the load is below the peak power. Overload can trigger the stack protection function to avoid the damage to the stack.
5. Check whether the fuel cell temperature is below 68˚C, the system will shut off if it is above 68˚C.

Check the SCU

1. During operation with the SCU on, the voltage of the fuel cell will drop.
2. If the fuel cell voltage is not dropping then contact support@horizonfuelcell.com with the diagnostic “SCU not operational” with the controller number.

Check the blower controller

Before the load is connected, turn on the blower controller. Otherwise the load will not run. During the operation process, do not turn off the blower controller.